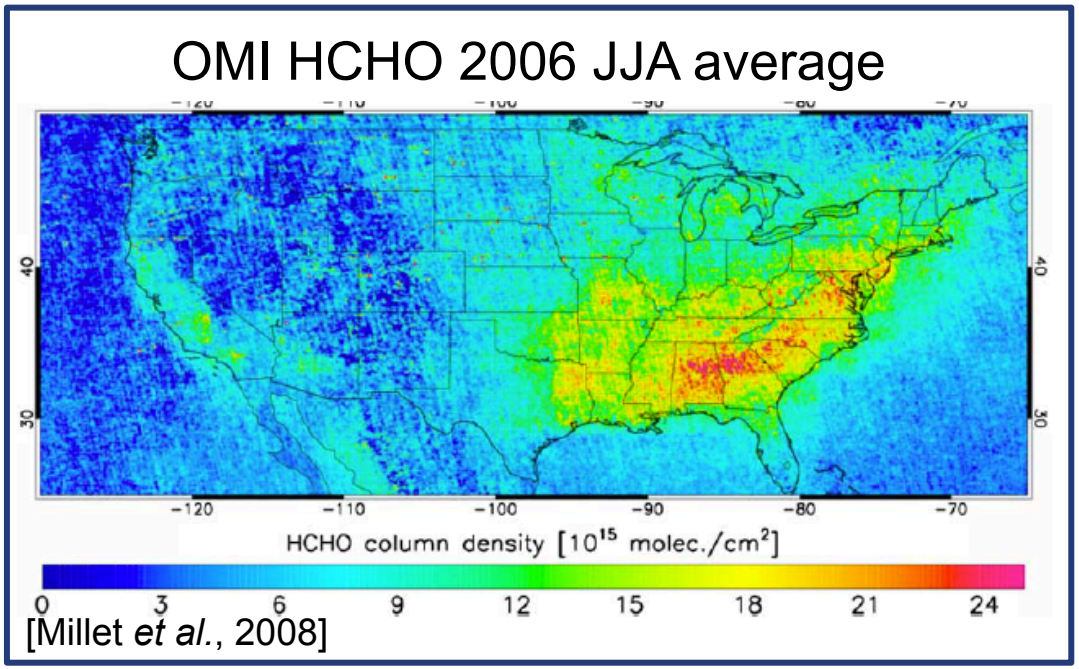
Anthropogenic emissions of highly reactive volatile organic compounds (HRVOCs) inferred from oversampling of OMI HCHO columns



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Aura Meeting

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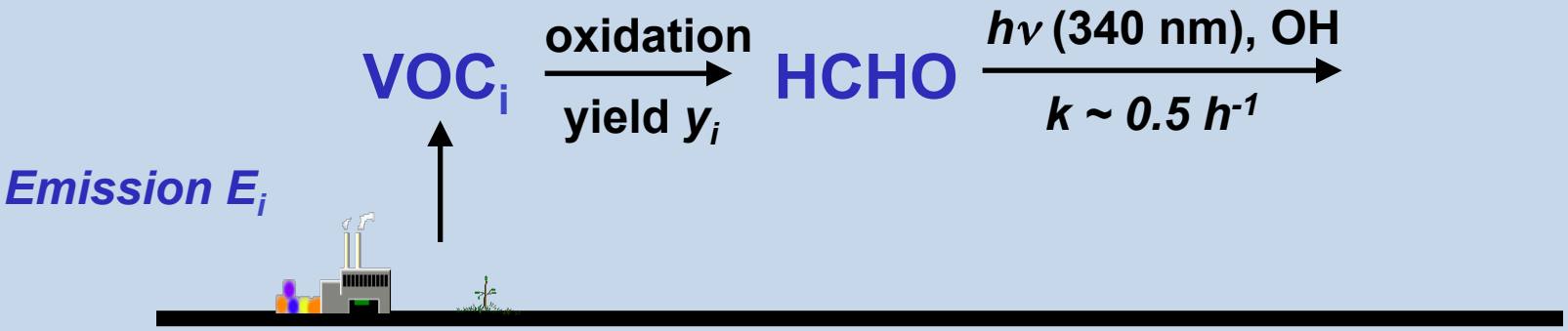
[2]Peking University; [3]Rice University; [4]NASA Goddard Space Flight Center;
[5]Harvard CFA ; [6]Belgian Institute for Space Aeronomy (BIRA-IASB).

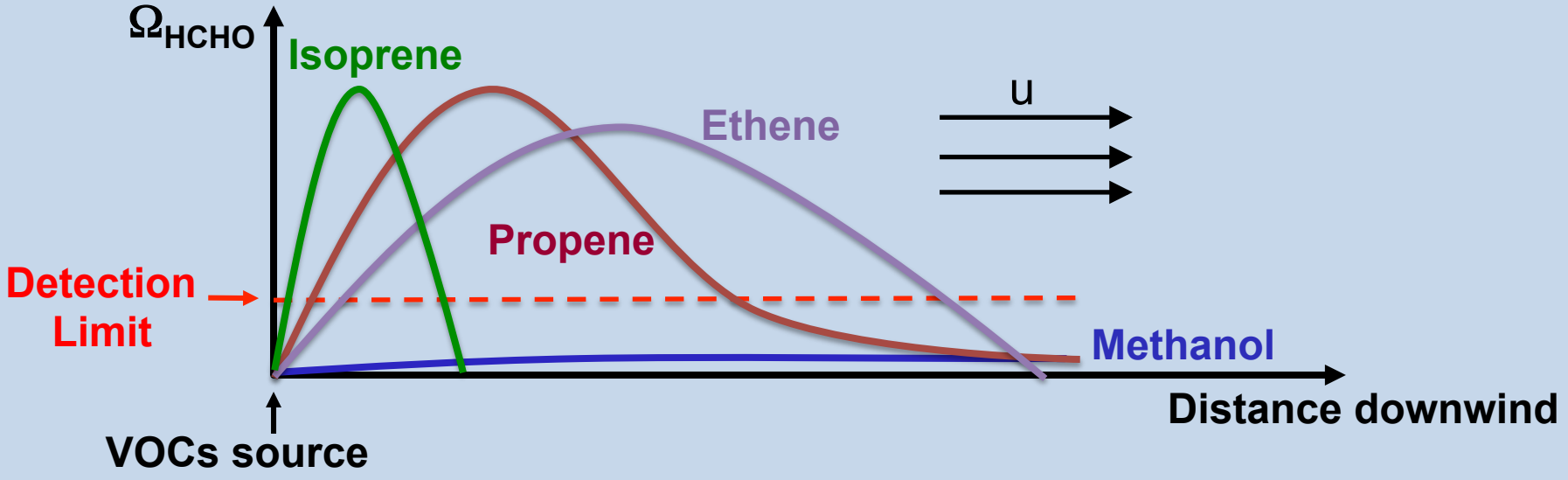
Relating HCHO columns to HRVOC emissions



In absence of horizontal wind, mass balance for HCHO column Ω_{HCHO}:

$$\Omega_{HCHO} = \frac{\sum_i y_i E_i}{k}$$

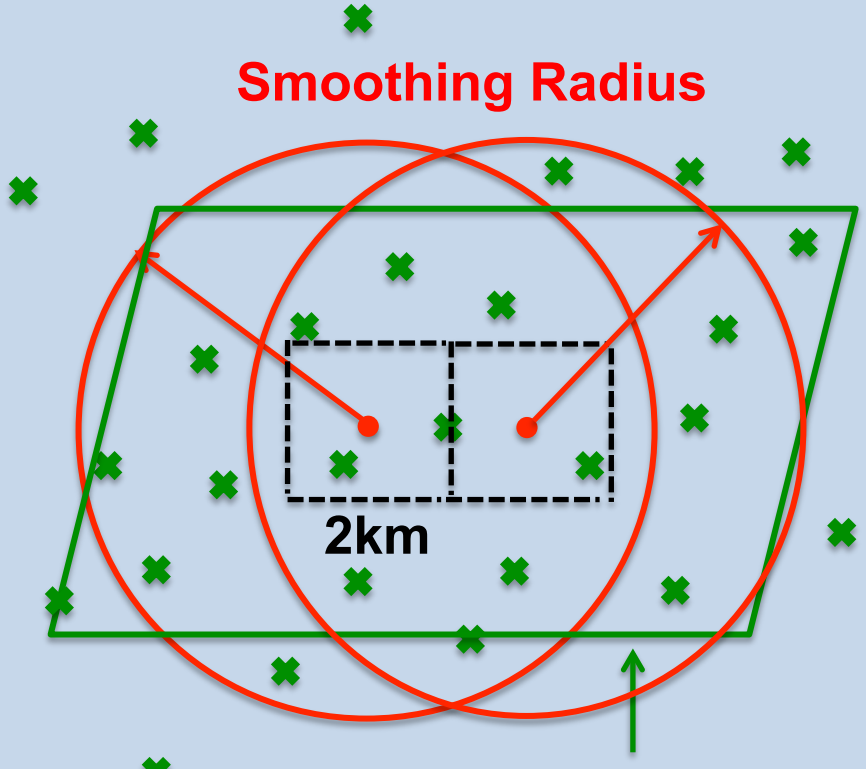
but wind smears this relationship



Oversampling approach to detect point/urban sources

- Oversampling: temporal averaging of the satellite data on a spatial grid **finer** than the pixel resolution of the instrument
- Takes advantage of the spatial offset and changing geometry of the satellite pixels from day to day
- **Trades** temporal for spatial resolution
- Achieves higher signal-to-noise ratio

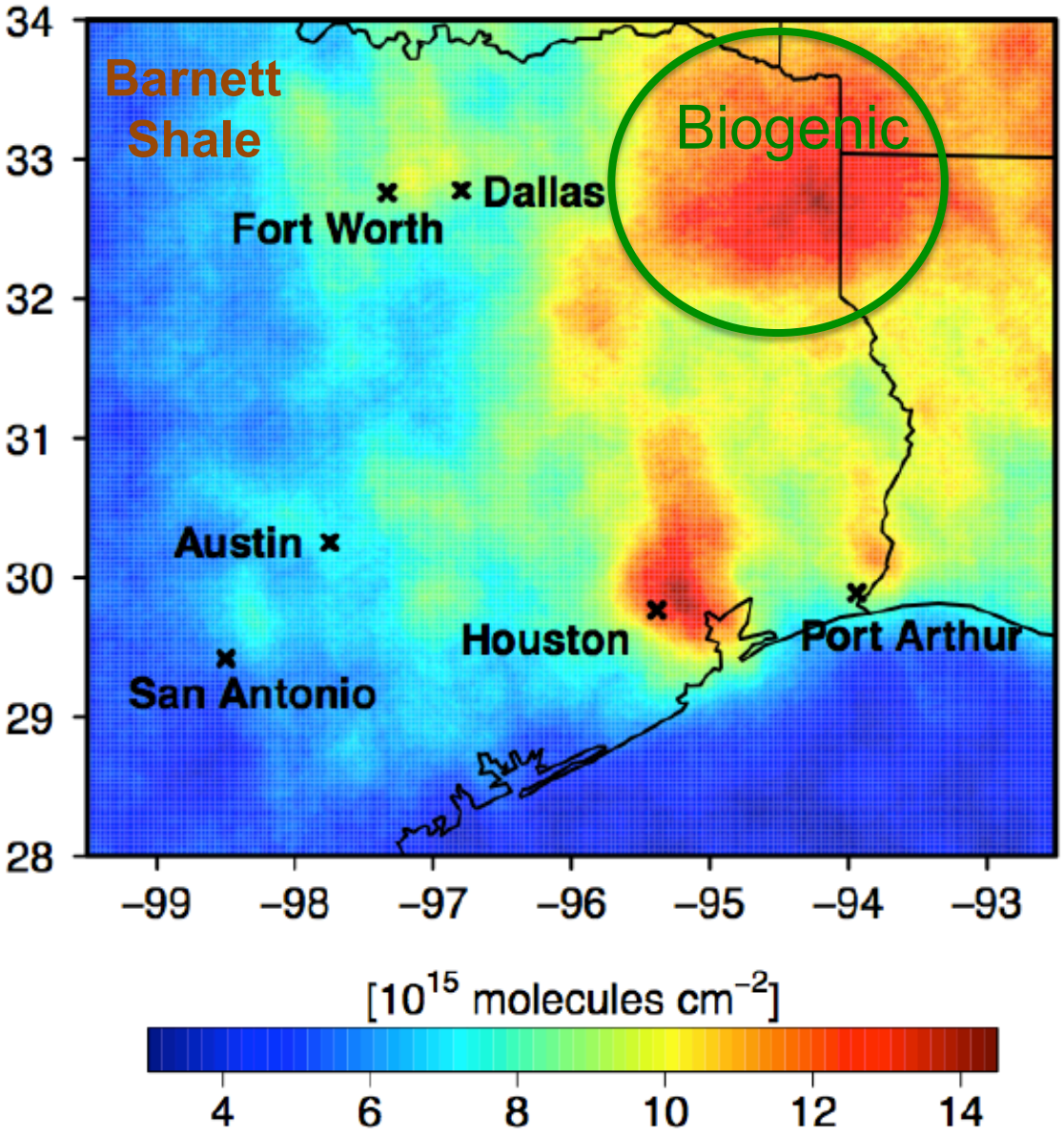
Optimize smoothing radius:
- Too fine (12 km): Increase noise
- Too coarse (36 km): Lose spatial features



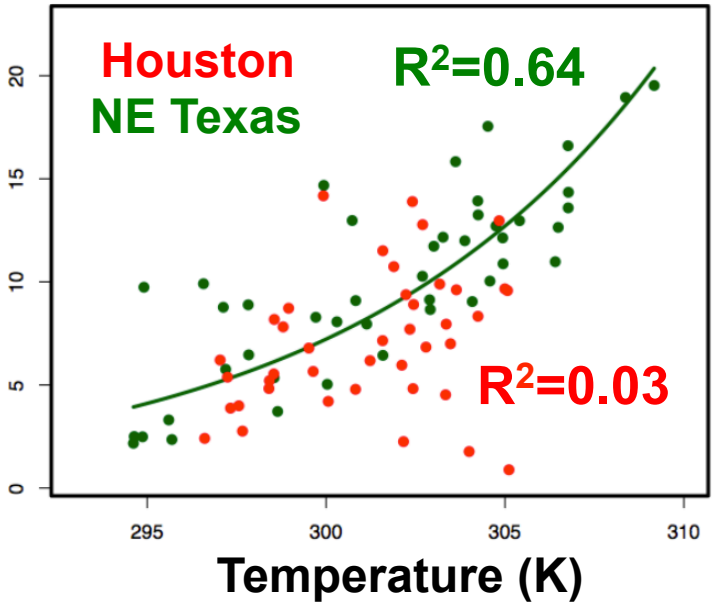
2005-2008 MJJAS
26028 pixels in a 1°×1° box

Results: Oversampling of OMI HCHO pixels

OMI HCHO column, 2005-2008, MJJA

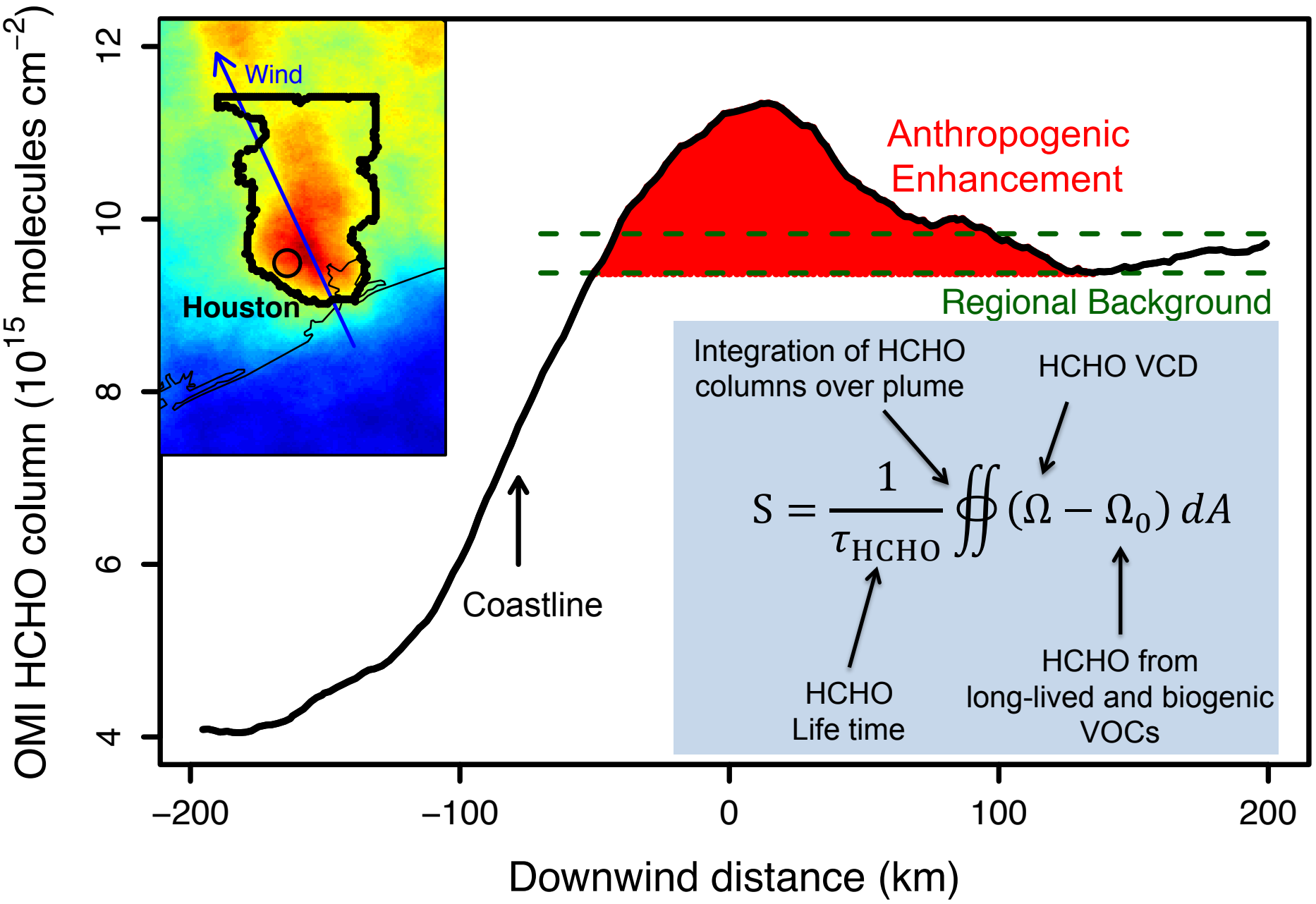


OMI HCHO column (10^{15} molecules cm^{-2})



Oversampling approach enables detection of anthropogenic HRVOCs from urban/industrial sources and oil/gas operations.

Deriving the HCHO source in the Houston plume



Inference of AHRVOC emissions from the HCHO columns

$$S = \frac{1}{\tau_{HCHO}} \oiint (\Omega - \Omega_0)\, dA$$

HCHO lifetime: 1.6±0.5 h

S: 250±140 kmol HCHO h^{-1}

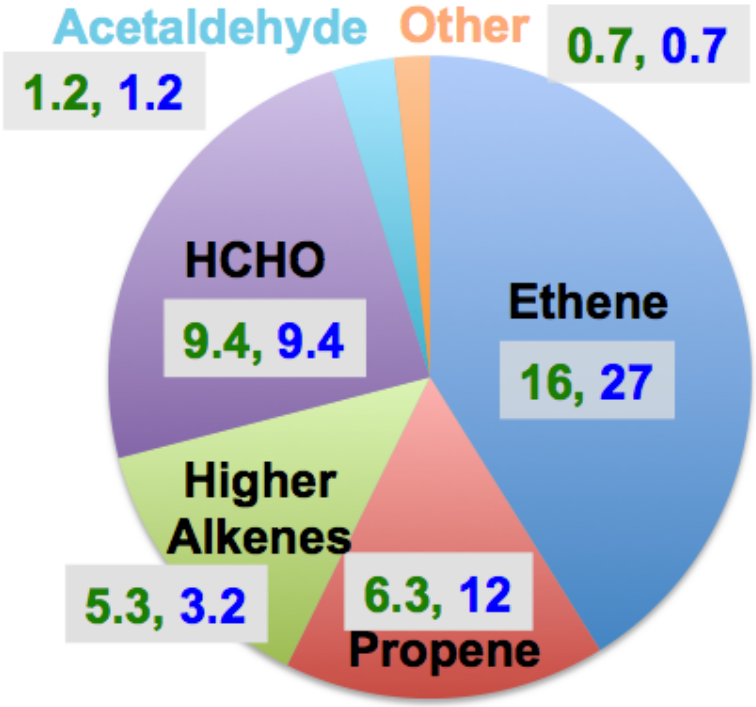
Bottom-up estimate:
240±90 kmol HCHO h^{-1} [Parrish et al., 2012]

Total AHRVOC emission

$$E = \frac{S}{\sum_i f_i Y_i}$$

Fraction of the total emission

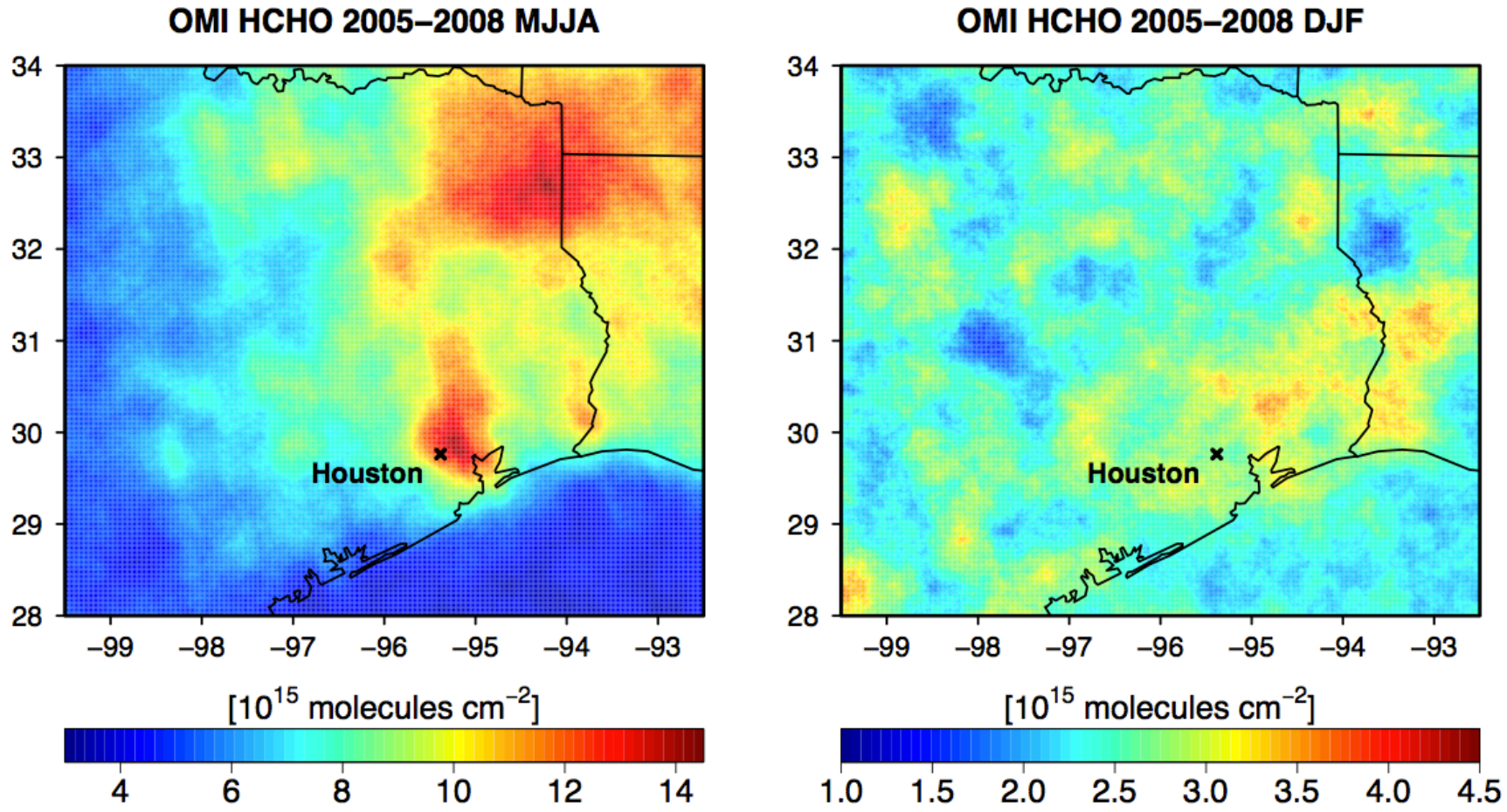
HCHO yield



EPA NEI05: emissions and HCHO production (kmol h^{-1})

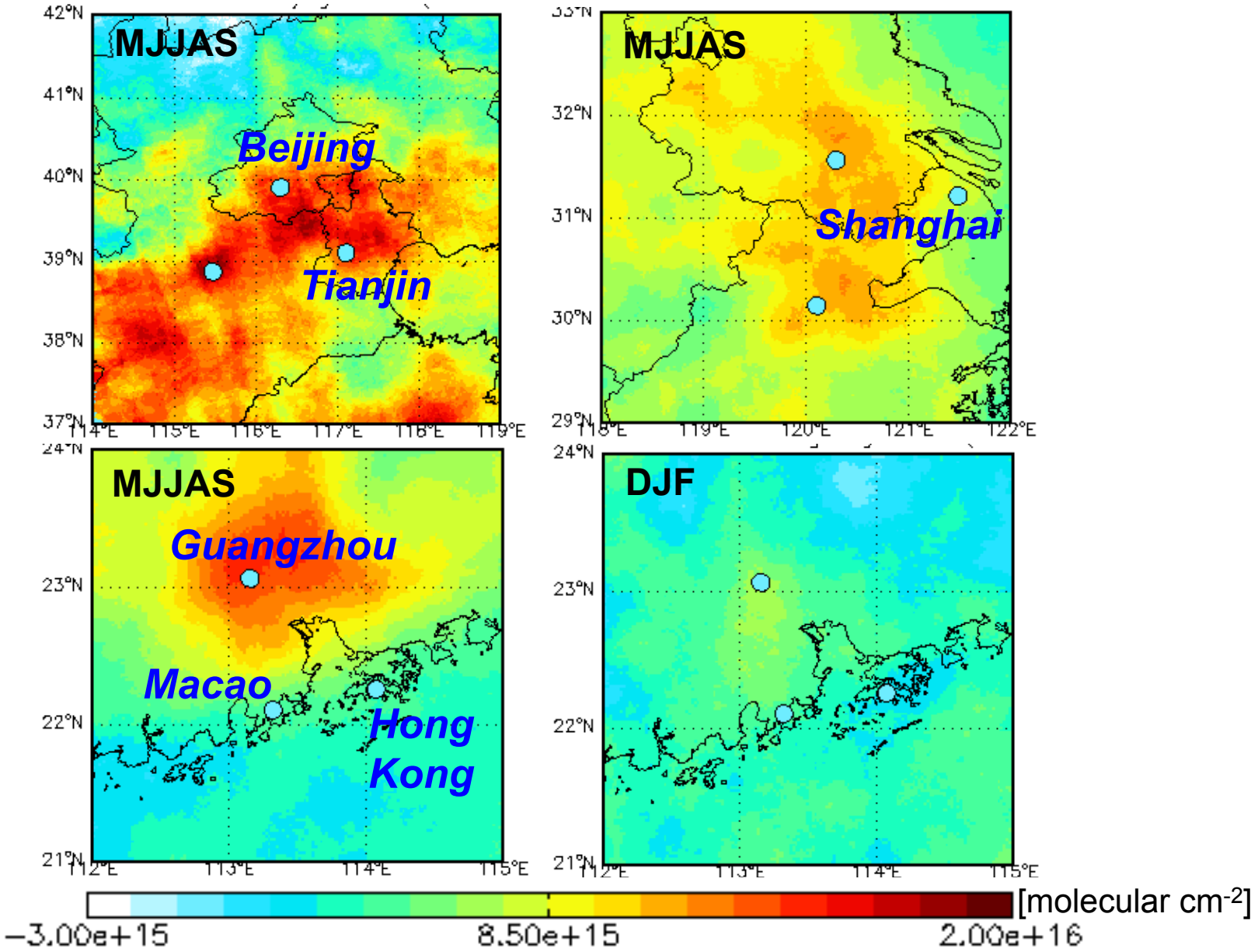
AHRVOC emissions in the Houston plume area are **underestimated** by a factor of **4.8±2.7** in EPA NEI05 inventory for 2005–2008.

Indistinguishable HCHO enhancements in winter at Houston



- HCHO enhancements at Houston are indistinguishable during winter even by oversampling, due to smearing resulting from low OH and high wind speed.
- This suggests that anthropogenic HCHO is mainly secondary rather than primary.

Oversampling of OMI HCHO pixels in China, 2005-2008



Aoxing Zhang and Lei Zhu

Take home messages

- Oversampling of OMI HCHO columns solves the long-standing problem of detecting and quantifying US AHRVOC emissions from space.
- AHRVOC emissions for Houston are **4.8 ± 2.7** times higher than that in EPA inventory.
- Due to low OH and high wind speed, OMI HCHO enhancements in winter are indistinguishable at Houston, which suggests that anthropogenic HCHO is mainly secondary.

Future work

- Improving the oversampling technique: *e.g.*, using Gaussian or inverse distance weights for spatial smoothing
- Detecting long-term trends of HCHO in urban/industrial areas and oil/gas fields
- Looking at HCHO over China
- Linking HCHO with other information, *e.g.*, wind speed, wind direction, or glyoxal columns